SELECTING CANDIDATE LOCATIONS FOR RED LIGHT CAMERAS

Jeff Suggett, M. Sc., Synectics Transportation Consultants Inc.
Brian Malone, P. Eng., Synectics Transportation Consultants Inc.
Greg Borchuk, P. Eng., Region of Durham

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ABSTRACT

In August 2004, the province of Ontario announced that interested municipalities would be able to operate red light cameras based on the positive findings of an evaluation into their safety effectiveness. The Region of Durham wished to explore the feasibility of implementing a red light camera program and particularly wanted to ensure that the sites were selected in an objective and defensible manner based on sound traffic engineering judgment. This paper discusses the development of site selection criteria, the identification of potential candidate locations using collision data, and further refinement of the list through a detailed office and field review.

The candidate locations were selected based on a higher than expected collision performance and an over representation in angle collisions. These locations would have the highest potential for safety improvement, specifically in red light running related collisions. A detailed office and field review was conducted, including a detailed collision analysis, a review of signal operations, intersection layout, traffic signal type and placement, prevailing traffic patterns and operating speeds, and the suitability of each approach for a red light camera. Based on the review, a short list of candidate sites/approaches was developed.

For approaches remaining on the short list, it was suggested that the occurrence of red light running be confirmed through a detailed field investigation, a benefit-cost analysis be undertaken to confirm that any alternative treatment identified would not be able to achieve similar results at a lower cost, and rear end collisions be closely monitored in the post-implementation period.

1 Background

Based on a concern raised by municipalities in Ontario over the occurrence of red light running related collisions, in 1998 the province of Ontario passed *The Red Light Cameras Pilot Projects Act, 1998 (Bill 102)* to enable designated municipalities to test and evaluate the effectiveness of various enforcement options to address the problem of red light running at signalized intersections for a two-year period (November 20, 2000 – November 19, 2002). Six municipalities in Ontario elected to proceed with a pilot project evaluating the effectiveness of red light cameras and stepped up police enforcement at a number of signalized intersections located within their own jurisdictions.

In February 2002, five of the original six municipalities formally requested that the Government of Ontario extend the pilot project for an additional two years as preliminary results indicated that the red light cameras were effective. On November 19th, 2002, the Red Light Cameras Pilot Projects Extension Act, 2002, received Royal Assent. This legislation enabled designated municipalities to continue to enforce red light camera violations until November 20, 2004. The legislation also allowed for repeal of the pilot end date, by an Order-In-Council, prior to November 20, 2004, which would make the legislation permanent.

Synectics Transportation Consultants Inc. was retained to conduct an evaluation of the effectiveness of the two red light running countermeasures (red light cameras and stepped up police enforcement). An additional set of neighbouring sites were selected as local control sites. Collision data at forty-eight sites were reviewed for a five-year period prior to the implementation of the red light cameras and compared to collisions occurring during the first two years of the pilot, using the Empirical Bayes method. Their study, released in December 2003, indicated that the two red light running countermeasures were effective at reducing angle collisions at the expense of rear end collisions **(1)**. Fatal and injury angle collisions decreased 25.3 percent while property damage only angle collisions decreased 17.9 percent. However, there was an increase in rear end collisions. Fatal and injury rear end collisions increased 4.9 percent while property damage only rear end collisions increased 49.9 percent. Despite the increase in rear end collisions, it was felt that as a whole the pilot project had been a success. It was estimated that a total of forty-seven fatal and injury collisions had been avoided as a result of the pilot project among the study sites.

Based on the encouraging results, the province of Ontario made a decision to repeal the pilot end date on August 10th, 2004. It announced that municipalities may operate red light cameras in Ontario indefinitely. Five of the six municipalities are currently continuing to operate red light cameras. Other municipalities wishing to also implement a red light camera program may do so conditional on a number of mandatory requirements including a requirement to conduct a publicity campaign notifying the public that a red light camera program is proceeding and signing of sites having a red light camera in operation.

2 The Purpose of This Paper

The Region of Durham is a municipality located immediately east of the City of Toronto with a population of approximately 500,000. In 1999, the Region of Durham was invited to participate in the original Red Light Camera Enforcement Pilot Project but opted out for several reasons. At that time, it was felt that there was not a significant number of red light running related collisions occurring in the Region, there was not sufficient fiscal resources to cover the costs of purchasing red light cameras, and was felt that red light cameras would only treat the symptom, not the underlying cause of red light running. Therefore, the Region of Durham had adopted a ‘wait and see’ approach to red light cameras, waiting out the initial pilot project and contingent on its success, making then a decision to go forward with their own red light camera program.

Upon completion of the evaluation of the pilot study, the Region of Durham Works Department retained Synectics Transportation Consultants Inc. to conduct a feasibility study into the use of red light cameras at candidate signalized intersections within the Region. The report was completed in March 2005 **(2)**. In the report, Synectics proposed that the feasibility study be carried out in five parts, being:

- **Part 1** - Identify technical requirements. Based on the experience of the other participating municipalities, determine what would be involved in implementing a red light camera program (i.e. provincial mandatory requirements, level of commitment of Region staff etc.);
- **Part 2** - Develop site selection criteria using collision data;
- **Part 3** - Identify potential candidate locations using collision data (the 'long list');
- **Part 4** - Narrow down the list of potential candidate locations based on a detailed office review and field investigation (the 'short list'); and
- **Part 5** - Estimate the benefits and costs associated with implementing a red light camera program at the remaining candidate locations on the short list.

Exhibit 1 presents a flow chart showing the process undertaken in determining the feasibility of implementing a red light camera program in the Region of Durham.

As part of the site selection process, the Region of Durham expressed concern over selecting sites that were inappropriate for a red light camera. Red light camera programs in the United States have received some negative publicity due to this issue. In some jurisdictions, sites were chosen with little regard for whether there was a legitimate red light running problem that could not be remedied through traditional engineering treatments. This lead to public outcry against the use of red light cameras and accusations that they were a 'cash grab'. Closer to home, some of the six municipalities in Ontario expressed dissatisfaction with a few of their red light camera sites in the original pilot study in 2000. Some of the sites yielded little or no red light running violations. For this reason, one of the municipalities in the original Ontario pilot study abandoned their red light camera program altogether.

For the above reasons, the Region of Durham wished to have an objective and defensive screening process for selecting their sites based on sound traffic engineering principles. The purpose of this paper will be to describe the steps taken in Part 2 through Part 4 of the feasibility study, being the development of site selection criteria using collision data, identification of potential candidate locations using the site selection criteria, and the narrowing down of the list of potential candidate locations based on a detailed office review and field visit.

3 Site Selection Criteria (Part 2)

Red light running and collisions attributable to red light running by motorists may result from a number of contributing factors. Consequently, they may be addressed by a variety of countermeasures encompassing engineering improvements, driver education campaigns and increased police and automated enforcement, directed against red light runners **(3)**. In order to fully understand where the problem is occurring and define the solutions, the collection and analysis of collision data should be considered as the primary input in the decision making process.

In developing the long list of candidate sites, the authors considered a number of different methods of site selection based on collision data. Several approaches to site selection using collision data have been suggested or utilized by other municipalities in Ontario and elsewhere. Methods have included:

- Overall collision frequency/rate;
- Target collision frequency/rate;
- Over representation; and
- Statistical modeling

Each of the above is discussed briefly below.

Overall collision frequency/rate

Choosing candidate sites based on collision frequency or rate alone is by far the commonest and albeit most simplistic method of determining candidate sites. The 2003 FHWA document *Guidance for using red light cameras* suggests using 'high risk' or historically dangerous sites as potential candidate sites **(4)**. Many of the jurisdictions in the original Red Light Camera Enforcement Pilot Project used collision frequency/rate or injury collision frequency/rate as a method of choosing sites. Several problems are associated with this approach. First of all, sites with a high number/rate of collisions may consist of a majority of collisions that would not be remedied by a red light camera (i.e., non red light running related collisions). Many signalized intersections have high numbers of rear end collisions due to congestion. These sites would be a poor candidate for a red light camera as rear end collisions tend to increase after their installation. Finally choosing candidate sites based on collision frequency would favour high volume intersections that have a large number of collisions occurring simply due to the amount of traffic the intersection is required to handle every day. Choosing candidate sites based on collision rates alone would in contrast favour low volume intersections as these would more likely have a higher collision rate. For this reason, this criterion was not selected.

Target collision frequency/rate

A more refined method of choosing candidate sites is examining only those collisions seen as most relating to red light running – being angle collisions. Angle collisions at signalized intersections involve two separate vehicles entering the intersection on two adjacent approaches colliding with each other. Because traffic signals separate all conflicting movements, one of the vehicles involved in the collision would have had to have proceeded through on a red indication, therefore red light running would have to had occurred. The frequency of angle collisions is therefore an indicator of a red light running problem occurring at an intersection, whether intentional or unintentional and as such should be considered as a possible screening criteria for the ‘long list’ of candidate sites.

Turning movement collisions can also be related to red light running where a vehicle making a left turn collides with an on-coming vehicle from the opposite direction (left turn opposing). A red light running collision may occur when the traffic signal has a left turn protected phase, and the left turning vehicle makes their turn outside of the protected phase, or the oncoming vehicle proceeds through the intersection during the protected phase. A red light running related collision may also occur when a left turning vehicle strikes a vehicle proceeding through the intersection on an adjacent approach. However, most other types of turning movement collisions are not a result of red light running, therefore a collision analyst would need to examine each individual police report to determine whether red light running actually occurred.

Rear end collisions at signalized intersections are not the result of red light running, but are rather the result of vehicles stopping for a signal at an intersection while others behind them do not. The evaluation study conducted by Synectics indicated that rear end collisions increased at signalized intersections having red light cameras **(1)**. Other research has suggested the same occurrence **(5)**. It has been speculated that this increase is due to inconsistencies in driver response to red light cameras (between leading and closely following vehicles). Rear end collisions may be therefore be considered as a possible criterion for eliminating potential sites.

Focusing on target collisions was determined to be more valuable than simply examining total collisions, however, this method, being still frequency/rate based, has some of the same drawbacks as the first approach as explained above.

Over representation

Sites having a higher than expected proportion of target (angle) collisions represent another means of selecting candidate sites for the ‘long list’ (known as over representation). Over representation involves the comparison of the expected proportion of a collision type (angle – based on Regional averages) compared to the actual observed proportion. Significant over representation is tested using the Chi Square test. This method would assist in selecting sites that are behaving ‘abnormally’ compared to what would be expected. Over representation of sites with an abnormally high number of rear end collisions could also be used to eliminate sites from the long list. One possible shortcoming with over representation is that a site having a relatively low number of collisions may be chosen (due to an abnormally high occurrence of angle collisions) at the expense of another site having a high number of collisions that would possibly achieve a more significant collision reduction, therefore the method should only be used in combination with another method.

Statistical modeling

Statistical modeling represents a more advanced method of site selection. In Ontario, many of the larger municipalities have developed a set of safety prediction equations that model the relationship between collision frequency (per year) and volumes for a number of different road facilities. These are used to identify locations having the most potential for safety improvement. These safety prediction equations exist in the Region of Durham **(6)**. These equations could be used to determine sites having a higher than predicted collision or injury/fatal collision frequency. Using these equations would be advantageous as they were developed specifically for the Region and therefore represent local traffic patterns. As well, this method would not have a bias towards low or high-volume locations. However, these equations are not based on the target group of collisions of interest for this study, as they have been developed for all fatal and injury (grouped together) and property damage only collisions. Sites with a higher than predicted number of collisions based on the prediction equations existing in the Region of Durham may be high for reasons other than a red light running problem. This method would therefore be enhanced if it was supplemented with another method that would focus in on target collisions of interest.

With the above method of site selection, volume data would need to be used. Accurate volume data would be required to predict the number of collisions. Sites having missing volume data will require factoring from other years or locations, may take a considerable amount of time and may yield inaccurate results. The authors concluded that the Region of Durham's volume data was of a sufficient quality to develop an accurate prediction of the potential for safety improvement.

Recommended site selection criteria

All of the approaches mentioned above have a shortcoming. Therefore, it was decided that more than one method be used to develop the initial list of sites. Based on the above, potential site selection criteria methods recommended for developing the 'long list' of candidate sites were:

- **Using statistical modeling** – Choosing sites having a potential for safety improvement based on existing Region of Durham safety prediction equations; and
- **Using over-representation (the Chi-Square test)** – Choosing sites having an unusually high proportion of angle collisions compared to Regional averages.

Sites to be excluded from the site selection process at the outset were those having had recent reconstruction or a traffic signal installed after 1999. Sites having an unusually high proportion of rear end collisions were initially considered for exclusion, however, it was decided to carry them forward into the office and field review as part of the short list (Part 4).

4 Development of the Long List (Part 3)

In order to develop the long list of candidate sites for a red light camera, Synectics requested four types of information:

- Signalized intersection data;
- Collision data;
- Volume data; and
- Safety prediction equations.

Each of these is discussed in the following section.

Signalized intersection data

The Region of Durham Works Department prepared for Synectics a listing of signalized intersections. The listing consisted of 297 signalized intersections operated by the Region of Durham.

For each signalized intersection, the Region provided an identification number (MapID), the name of the intersection, the environment (land use), the number of approaches, and the municipality where the intersection is located. The environment and number of approaches were required to determine the PSI (potential for safety improvement) value for each intersection. The PSI value is calculated from the safety prediction equations (as explained below).

Synectics reviewed the signalized intersections in order to exclude those intersections having a traffic signal installation date of later than 1998 or recent significant reconstruction. In considering the collision history at each of the intersections, collisions occurring during the years 1999 – 2003 were reviewed. Intersections with a recent traffic signal installation date or recent reconstruction were considered to likely have a collision history not reflective of a typical signalized intersection. A total of 41 intersections were found meeting these criteria and were therefore excluded from the list.

Collision data

In addition to the signalized intersection listing, the Region of Durham Works Department prepared for the study team the collision totals for each signalized intersection for the years 1999 - 2003, subgrouped by:

- Fatal collisions;
- Injury collisions;
- Property damage only collisions;
- Angle collisions; and

- Rear end collisions.

Non-reportable collisions were not included in the analysis.

The study team used the angle and rear end collision totals to determine the collision distribution at a typical signalized intersection (excluding those signalized intersections having had a signal installed after 1998). The typical collision distribution at a signalized intersection was determined to be:

- Angle collisions (18 percent);
- Rear end collisions (32 percent); and
- Other collisions (50 percent).

The above collision type distribution was used in the Chi-Square Test to determine whether or not each individual signalized intersection was exhibiting an abnormally high proportion of angle or rear end collisions compared to what would typically be expected at a signalized intersection in the Region of Durham.

Signalized intersections having an over representation in angle collisions according to the Chi-Square Test were considered to be potential candidate intersections in the long list. Intersections having an over representation in rear end collisions were considered not to be a good candidate intersection for the long list – as rear end collisions typically increase in frequency at intersections having a red light camera. Initially, the study team recommended that those intersections having an over representation of rear end collisions should be excluded from the list. However, it was decided that these locations should remain in the long list, to be given a closer examination in the office and field review – as the rear end collision problem may be isolated to only one or two approaches, leaving the remaining locations viable for red light camera operation.

Volume data

The major and minor entering average annual daily traffic (AADT) volume was required to determine the PSI (potential for safety improvement) value for each intersection. The Region of Durham was able to provide estimates of the entering AADT on the major and minor approach for almost all of the intersections. The major and minor AADT was taken to be representative of the five-year period (1999 – 2003) under consideration. Where entering AADT estimates were not available, either Synectics or the Region of Durham used turning movement count data to estimate the entering AADT, if it appeared that the site might be a potential candidate.

Safety prediction equations

In order to determine the PSI index, Synectics used the safety prediction equations previously developed in the Region of Durham **(6)**. A set of eight safety prediction equations had been developed for three and four approach signalized intersections and for four different land use classifications (CBD being the central business district, suburban, semi-urban, and rural/rural centre).

The equations required the following inputs:

- Average yearly fatal and injury collisions;
- Average yearly property damage only collisions;
- Average major entering AADT;
- Average minor entering AADT; and
- A number of parameters specific to each approach and land use group.

Use of the safety prediction equations allowed the study team to estimate the expected yearly number of fatal and injury (combined) collisions and the expected yearly number of property damage only collisions. Comparison to the observed yearly number of fatal and injury collisions (combined) and the expected yearly number of property damage only collisions (adjusting for yearly fluctuations in collisions) allowed the PSI value to be determined. The PSI value is calculated simply as the difference between the observed and expected yearly number of collisions.

Signalized intersections having a positive PSI value for either fatal and injury (combined) or property damage only collisions indicate that the location is experiencing a higher yearly frequency of collisions than would otherwise be expected. Hence, through careful consideration of the factors likely contributing to the increased collision frequency and subsequent treatment of those factors through either an engineering or enforcement countermeasure, these locations should experience a decrease in yearly collision frequency. Sites having a negative PSI value indicate that the location is experiencing a lower frequency of collisions than would be expected. These sites likely do not have any major correctable safety problems – and would not be good candidates for the long list of sites.

It was initially thought that the signalized intersections to be included in the long list of candidate sites should have both a positive fatal and injury (combined) PSI value in addition to a positive property damage only PSI value. It was subsequently decided to relax the criteria to include sites having a positive fatal and injury (combined) PSI but a negative property damage only PSI value – to allow a through site review to be done on these locations also.

Based on the above, nineteen candidate sites made it onto the ‘long list’, as shown in **Exhibit 2.** Two of the nineteen candidate sites had also an over representation in rear end collisions.

5 Development of the Short List (Part 4)

Further narrowing the sites down involved conducting a detailed and focused office and field review, examining the collision history, traffic signal type and placement, intersection and approach geometrics, operations and suitability of approach for red light cameras.

The office and field review assisted the study team in:

- Diagnosing why the intersection was experiencing a higher than expected number of fatal, injury and property damage only collisions, in addition to an over-representation of angle collisions;
- Determining which approaches were implicated in the red light running;
- Determining what might be an appropriate treatment to address the problem; and
- Determining whether or not a red light camera would be an appropriate choice for the site.

Office review

As part of the office review, Synectics requested the following information from the Region of Durham for each of the nineteen sites:

- Detailed collision histories;
- Information on the signal operations (actuated or pre-timed and coordinated or isolated) and the presence of a dilemma zone;
- Detailed information on phasing and the level of service (by means of a Synchro file representing morning and afternoon peak hour conditions);
- Site plans showing signal head type and placement, lane configuration and approach geometrics; and
- Speed data (85^{th} percentile speed and posted speed).

The following describes how the above information aided in the diagnosis of problems at the sites.

The detailed collision histories were reviewed to determine which approaches were implicated in the angle collisions occurring at the site and which driver was at fault. Individual movements were tallied for each angle collision (i.e., eastbound, westbound, northbound, and southbound) to determine which approach was most often implicated in the collisions. Police normally record Driver 1 as being the individual most at fault in the collision, and any subsequent drivers (Driver 2, Driver 3…etc.) as being the least at fault. In angle collisions at signalized intersections, it can be assumed that the most 'at fault' driver was red light running while the other driver(s) were proceeding through on a green signal. This was a key piece of information, as it allowed Synectics to differentiate between red light running 'victims' and 'offenders' by individual approach. Approaches having a high number of 'at fault' drivers involved in angle collisions were considered to be approaches having a high number of red light running violations (compared to the other approaches at the intersection) and would be an important criterion for a red light camera.

Part of the original site selection criteria included a requirement that there not be an over representation of rear end collisions at the intersection, as rear end collisions typically increase at sites having a red light camera. This criterion had been relaxed to allow two more sites to be included in the office and field review. Rear end collisions were also examined on an individual approach basis at all candidate intersections, particularly the two sites having an over representation of rear end collisions. Approaches having a significant number of rear end collisions were considered to be poor candidates for a red light camera.

A final consideration was the presence of wet or slippery road surface conditions at the intersections – for all collision types and specifically for angle collisions. Typically, intersections have between 20 – 30 percent of their collisions occurring on a wet or slippery road surface. However, some of the nineteen sites have a significantly higher number of collisions occurring during wet or slippery road surface conditions, specifically among angle type collisions. This suggested that drivers were either unable to stop in time, or were driving at excessive speeds for the road conditions. In these instances, a red light camera may be an option, but also treatments that address wet or slippery road surface conditions may be also identified.

The study team also reviewed the signal operations and phasing at each of the locations. The existence of signal coordination assisted the study team in understanding traffic patterns in the field. Signal coordination typically creates vehicle platooning which in turn may induce red light running in vehicles at the end of the platoon that arrive at an intersection at the onset of the red signal indication. Poorly coordinated traffic signals may also lead to driver frustration and in turn red light running at signalized intersections.

The length of the phasing during the AM and PM peak were also reviewed. Appropriate timings for signal phasing were calculated using Ontario Traffic Manual Book 12 **(7)**, based on the operating speed of the roadway and the width of the intersection. Recommended amber and all-red signal timing were calculated and compared to the actual timings. In almost all cases, it was determined that the existing signal timings were adequate. In situations where the signal timings were significantly shorter than recommended, an adjustment was recommended.

Level of Service for each movement was also diagnosed. A LOS of A suggests that little or no queuing is occurring at the intersection, which may lead to greater opportunities for red light running. Conversely, a LOS of F may also lead to red light running, as frustrated drivers continue through the intersection during the all-red phase. In the review of the nineteen intersections, generally speaking the LOS tended to be good to excellent (LOS A or B) on the approaches where the at fault angle movements were originating.

The speed data was also useful, first for calculating the recommended amber and all-red phasing and also for providing the study team with further insight into the behaviour of drivers on the intersection approaches. Approaches having a high 85^{th} percentile speed (in relationship to the posted speed) suggested aggressive driving behaviour which may be leading to red light running. Drivers traveling well above the speed limit on an intersection approach are likely less inclined to stop during the amber phase.

The study team also requested intersection design drawings for each candidate location. The design drawings allowed the study team to determine the number of signals, their placement and type, the intersection width (for calculating the appropriate amber and all-red phasing), and provided an early indication as to the visibility on each approach. The intersection design drawings were also useful as a reference tool back in the office after the field review had been completed.

Field review

The field review was conducted on a Tuesday. Conditions were clear and the roads were dry and bare. The study team visited all nineteen sites over the course of the day, reviewing each approach, but paying particular attention to the approaches having the high number of 'at fault' driver movements resulting in an angle collision. The purpose of the field review was to further confirm any diagnoses made as part of the office review, to further identify causal factors that may be contributing to red light running, and to make suggestions as to appropriate treatments that may address the problem of red light running, including the use of red light cameras. Four different issues were reviewed in the field, being:

- Traffic signal type and placement;
- Intersection and approach geometrics;
- Operations; and
- Suitability of approach for red light camera.

The study team reviewed the traffic signal type (standard incandescent or Light Emitting Diode - LED), placement (right side, median, on mast arm above traveled portion of road), and considered the overall conspicuity of the signals. All of the intersections had standard incandescent signals, which tend to be less conspicuous than LED signals, therefore LED signal upgrades were recommended. The primary and secondary signals were mainly highway head type (a 300 mm red indication with 200 mm amber and green indications). For the most part, it was noted that there was a clear line of sight on each approach to all signal head displays for a considerable distance upstream. However, sight distance was restricted on a few approaches due to horizontal or vertical skew.

Other traffic signal type and placement related problems observed were:

- Visual clutter in close proximity of the signal displays;
- A potential for confusion between signals at the intersection and another set of signals further downstream; and
- Near side signal heads for the opposite approach 'eclipsing' the far side signal heads for the approach under consideration.

The study team also considered the overall intersection and individual approach geometrics. Horizontal curvature on an intersection approach compromises a driver's ability to clearly see the intersection layout and the accompanying signal displays. A steep downhill grade on an approach may discourage a driver from stopping, particularly truck drivers. Obstacles within the intersection sight triangle (i.e. trees, hedges, signal controllers) will also prevent drivers proceeding through a green indication from seeing other drivers failing to stop on an adjacent approach. Drivers on all approaches should be able to see vehicles on adjacent approaches up to 3 seconds upstream of the intersection, allowing them to performing an evasive maneuver (in the event of a red light running incident).

While the study team did not have the opportunity to spend a prolonged period of time at each site, they were able to observe prevailing traffic patterns and operating speeds, and did observe a few instances of red light running. In industrial areas a significant amount of truck traffic was observed which may potentially block an adjacent or following driver's view of a signal. Some of the nineteen candidate locations had one-way streets. Traffic on these streets was noted to be traveling in platoons and sometimes in an aggressive manner (i.e., driving at an excessive speed, tailgating, rapidly changing lanes). This behaviour, together with the recorded instances of red light running provided further insight into whether red light running at the site is unintentional or intentional.

Finally, in the field review the study team investigated the suitability of the approach for a red light camera. Here, they considered the line of sight between where the red light camera would be potentially located and the stop bar, the presence of metallic objects in the approach, the number of lanes on the approach and the width of the adjacent approach. Generally speaking, there were no locations identified that would not be technically suitable for a red light camera, apart from some potential issues identified at two rural sites. The rural cross section at these sites combined with the high operating speeds would increase the likelihood of an impact with the pole on which either the flash unit or red light camera is mounted. If installed, the red light camera would have to be well outside the clear zone, both to protect drivers and the equipment.

The one-way approaches observed at some of the candidate sites provided an opportunity for the camera to be installed on each side of the approach, although generally speaking these locations had three or four lanes, and as such the camera would not be able to completely capture all violations.

Recommendations for the Short List

Upon completion of the office and site review, the study team compiled all of the data into a set of office and field review notes, one for each site.

The study team summarized the review of the detailed collision histories for each of the sites, commenting on the prevalence of angle collisions, specifically which movements had a high number of 'at fault' drivers, the prevalence of rear end collisions by approach, and if relevant the occurrence of a high proportion of wet and slippery road surface collisions.

Considering all of the office and field data available to the study team, a set of possible causal factors contributing to the occurrence of red light running was presented, in most cases specific to a particular approach.

Based on the diagnosis and identified causal factors, the study team then provided a list of suggested improvements that may address the occurrence of red light running at the intersection, specific to a particular approach (where possible). The improvements are all treatments identified as being possible engineering countermeasures that would address red light running according to current state-of-the-practice. In some instances, police enforcement was also recommended.

Finally, the study team made suggestions regarding the installation of red light cameras specific to each possible approach. For approaches where the study team did not suggest a red light camera would be appropriate, it was for the following reasons:

- **Insufficient evidence of red light running –** There were few or no 'at fault' drivers implicated in an angle collision on the approach in question. This suggested that the problem of red light running existed on another approach. Drivers on the approach in question are the 'victims', the likely scenario is that they were proceeding through the signal during the green indication and were struck by a vehicle on an adjacent approach proceeding through the intersection on a red indication;
- **Engineering alternatives should be explored further –** In some instances, there were a number of significant issues relating to the traffic signal type and placement, intersection and approach geometrics or operations that would suggest that an engineering alternative should be explored further. In these cases, it is likely that the driver on that particular approach was an inadvertent red light runner; and/or
- **There were a high number of rear end collisions –** Past research suggests that rear end collisions increase at sites having a red light camera. An approach already having a significant number of rear end collisions will likely see further increases in rear end collisions after a red light camera is installed, negating any safety benefits associated with a decrease in angle collisions.

Alternatively, some approaches were suggested as being viable candidate for a red light camera. For these approaches, red light cameras may be considered given the following:

- **The occurrence of red light running is confirmed through a detailed field investigation –** The field investigation should be conducted during peak traffic periods for at least eight hours. A field investigation will provide information on:
    - Types of violations (during an all-red or stale red phase, or green jumpers);
    - Associated movements (left, through, right); and
    - Relative number of violations occurring on a particular approach compared to another approach at the same intersection or another candidate location elsewhere – approaches having a low number of violations compared to another approach/intersection should be considered to be a lower priority for a red light camera.
- **A benefit –cost analysis being undertaken –** Red light cameras have high capital and operating costs relative to many other treatments. It was recommended to the Region of Durham that they conduct a benefit-cost analysis on each of the alternative treatments put forth by the study team, in addition to any others identified by themselves, for the purposes of determining whether or not any alternative treatments would achieve similar benefits at a lower cost. If alternatives are identified as being more cost beneficial, it was recommended that the Region consider implementing them and following up in twelve months to determine if they have been effective;
- **Rear end collisions are monitored at the site –** Where red light cameras are installed, rear end collisions should be closely monitored, particularly since the Region of Durham will be required to place red light camera signage at the locations – which in turn may cause some drivers to react unpredictably (i.e. slamming on their brakes to avoid proceeding through the intersection), leading to a greater risk of rear end collisions. An increase in rear end collisions may negate any benefit realized from the expected decrease in angle collisions, and may be cause for the Region relocating the red light camera to an alternative location.

Upon completion of the office and field review, seventeen of the nineteen sites remained on the short list. A benefit-cost analysis was conducted, in order to allow the Region of Durham to determine whether or not red light cameras, applied to the seventeen locations, would be cost-beneficial to install and operate for a given set of years, weighing costs (capital and operating costs) against the benefits of collisions avoided (and fatalities/injuries prevented).

6 Concluding Remarks

Upon completion of the report, the study team had developed an objective and defensible process based on traffic engineering principles for identifying candidate locations for red light cameras. Region of Durham Works Department has currently in hand a list of seventeen locations identified as being potential candidates for a red light camera, based on:

- A higher than predicted number of fatal, injury and/or property damage only collisions than would otherwise be expected at signalized intersections elsewhere in the Region;
- An unusually high proportion of angle collisions compared to that typically found at signalized intersections elsewhere in the Region;

Specific approaches were excluded, based on:

- Insufficient evidence of red light running;
- Identification of engineering alternatives that may address the problem of red light running in a more-cost effective manner; and
- The occurrence of a high number of rear end collisions that would likely increase upon installation of a red light camera.

For the approaches remaining on the short list, Synectics suggested:

- That the occurrence of red light running be confirmed through a detailed field investigation during peak traffic period for at least eight hours;
- A benefit-cost analysis be undertaken to confirm that any alternative treatments identified would not be able to achieve similar results at a lower cost;
- Rear end collisions be closely monitored in the post-implementation period.

The Region of Durham will also consider the geographic distribution of the sites, as some of the sites were in close proximity to each other, possibly reducing their effectiveness.

Currently, the Region of Durham has not made a decision to proceed with a red light camera program. Should they choose to proceed with the program, they will be able to draw upon a candidate list of sites chosen based on sound engineering judgment that is objective and defensible.

References

1. Synectics Transportation Consultants Inc., *Evaluation of the Red Light Camera Enforcement Pilot Project: Final Technical Report*, December 2003
2. Synectics Transportation Consultants Inc., *Feasibility Study on the Use of Red Light Cameras in the Region of Durham*, March 2005
3. Institute of Transportation Engineers, *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running*, 2003
4. Federal Highway Administration, *Guidance for Using Red Light Cameras*, March 20, 2003
5. *NCHRP Synthesis of Practice Report 310: Impact of Red Light Camera Enforcement on Crash Experience*, 2003
6. iTrans Consulting Inc., Safety *Improvement Program and Software*, Region of Durham, 2001
7. Ontario Ministry of Transportation, *Ontario Traffic Manual Book 12: Traffic Signals*, 2001

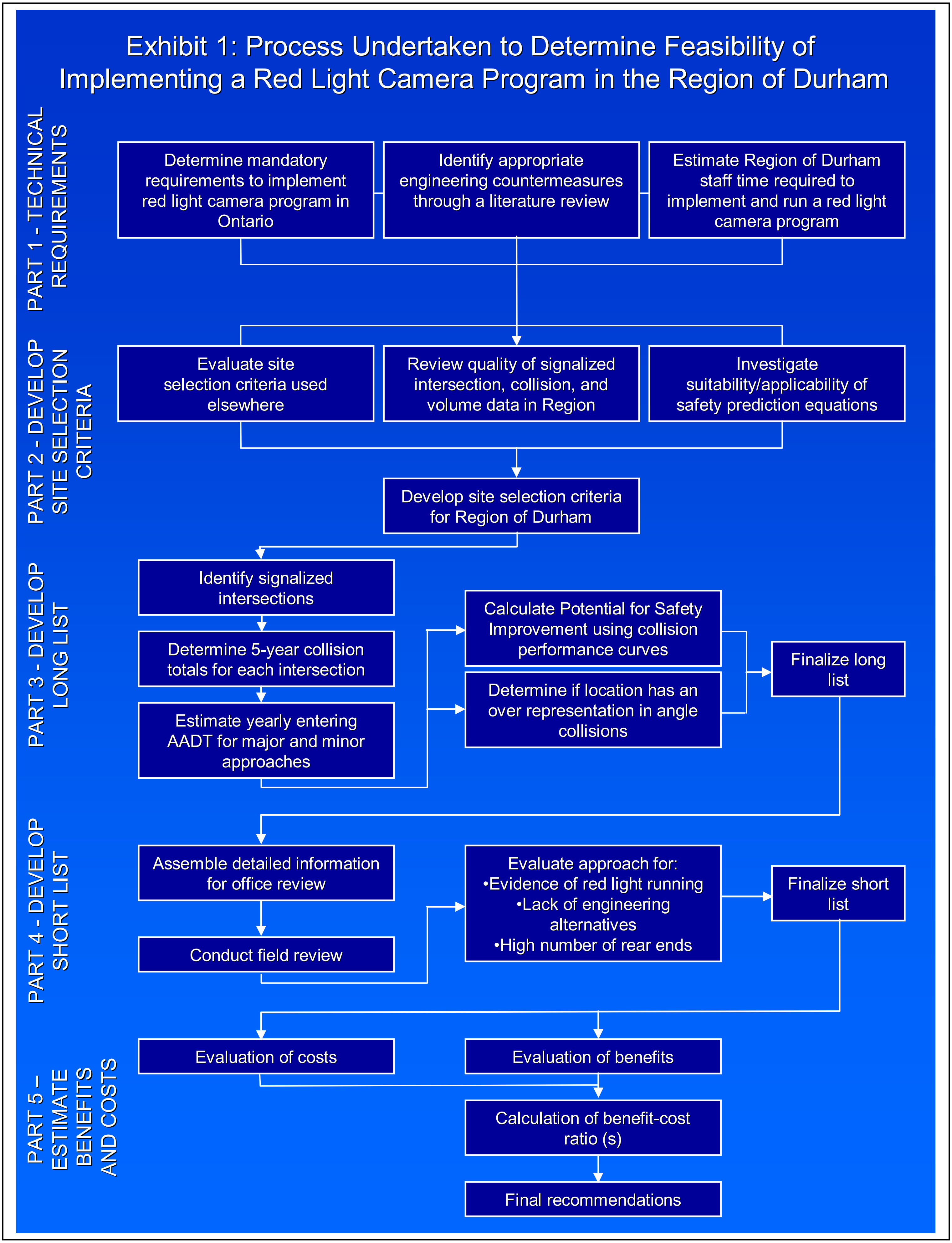
Exhibit 1: Process Undertaken to Determine Feasibility of Implementing a Red Light Camera Program in the Region of Durham
PART 1 - TECHNICAL REQUIREMENTS
Determine mandatory requirements to implement red light camera program in Ontario
Identify appropriate engineering countermeasures through a literature review
Estimate Region of Durham staff time required to implement and run a red light camera program
PART 2 - DEVELOP SITE SELECTION CRITERIA
Evaluate site selection criteria used elsewhere
Review quality of signalized intersection, collision, and volume data in Region
Investigate suitability/applicability of safety prediction equations
Develop site selection criteria for Region of Durham
PART 3 - DEVELOP LONG LIST
Identify signalized intersections
Determine 5-year collision totals for each intersection
Estimate yearly entering AADT for major and minor approaches
Calculate Potential for Safety Improvement using collision performance curves
Determine if location has an over representation in angle collisions
Finalize long list
PART 4 - DEVELOP SHORT LIST
Assemble detailed information for office review
Conduct field review
Evaluate approach for:
•Evidence of red light running
•Lack of engineering alternatives
•High number of rear ends
Finalize short list
PART 5 – ESTIMATE BENEFITS AND COSTS
Evaluation of costs
Evaluation of benefits
Calculation of benefit-cost ratio (s)
Final recommendations

Exhibit 2 – 'Long list' of candidate sites

Location						Observed Number of Collisions (1999 – 2003)								Over-Representation		AADT		PSI	
MapID	**Name of Intersection (not shown)**	**Environment**	**Approach**	**Mun**	**Jurisdiction**	**Fatal**	**Injury**	**Fatal & Injury**	**PDO**	**Total**	**Angle**	**Rear-end**	**Other**	**Angle**	**Rear-end**	**Major**	**Minor**	**Fatal & Injury**	**PDO**
6715524863302	[redacted]	Suburban	4	OA	Regional	0	17	17	49	66	15	11	40	Yes	No	15110	3100	1.56	6.01
6720914863497	[redacted]	CBD	4	OA	Regional	0	18	18	28	46	17	14	15	Yes	No	16867	14563	0.72	-0.12
6484074878385	[redacted]	Rural	4	UX	Regional	0	8	8	15	23	7	0	16	Yes	No	6647	3661	0.36	1.02
6712854862722	[redacted]	CBD	4	OA	Regional	0	9	9	14	23	16	2	5	Yes	No	9603	1953	0.41	0.75
6716904861665	[redacted]	CBD	4	OA	Regional	0	8	8	38	46	14	6	26	Yes	No	12324	8750	0.06	3.16
6715454862062	[redacted]	CBD	4	OA	Regional	0	10	10	33	43	17	7	19	Yes	No	11755	2599	0.48	2.91
6728774861292	[redacted]	CBD	4	OA	Regional	0	14	14	38	52	10	6	36	Yes	No	20515	5370	0.40	2.16
6718484861716	[redacted]	CBD	4	OA	Regional	0	8	8	20	28	10	1	17	Yes	No	13404	5110	0.14	0.71
6590584856887	[redacted]	CBD	4	AJ	Regional	0	16	16	32	48	15	10	23	Yes	No	23294	4028	0.62	1.06
6546734880034	[redacted]	Rural	4	US	Regional	0	9	9	12	21	7	9	5	Yes	Yes	7863	5491	0.32	0.23
6535854854928	[redacted]	CBD	4	PI	Regional	1	17	18	44	62	16	9	37	Yes	No	25683	8421	0.20	1.14
6711064864489	[redacted]	Suburban	4	OA	Regional	0	19	19	50	69	19	8	42	Yes	No	17854	6429	1.66	5.59
6705544862869	[redacted]	Suburban	4	OA	Regional	0	15	15	21	36	20	7	9	Yes	No	13701	9600	1.08	0.57
6707344862334	[redacted]	CBD	4	OA	Regional	0	21	21	34	55	28	6	21	Yes	No	15543	14251	1.26	1.30
6711924866125	[redacted]	Suburban	4	OA	Regional	0	14	14	20	34	12	6	16	Yes	No	18900	10344	0.64	-0.41
6716734864681	[redacted]	Suburban	4	OA	Regional	1	14	15	35	50	19	16	15	Yes	No	19568	18200	0.34	1.16
6697684862593	[redacted]	Suburban	4	OA	Regional	0	20	20	43	63	23	12	28	Yes	No	15515	9927	1.77	4.22
6731124859944	[redacted]	Semi-Urban	4	OA	Regional	0	18	18	33	51	19	15	17	Yes	No	12636	10025	1.81	2.85
6731864862926	[redacted]	CBD	4	OA	Regional	0	8	8	18	26	10	11	5	Yes	Yes	11993	1713	0.33	1.11

KEY:
MAPID - Identification code for location
MUN - Municipality where the intersection is located
JURISDICTION - Jurisdiction responsible for operation of intersection
OVER REPRESENTATION, ANGLE/REAR END - Having an abnormally high proportion of angle or rear end collisions based on what would typically be expected at signalized intersections elsewhere in the Region of Durham
AADT, MAJOR/MINOR - Average annual daily entering traffic on major and minor approaches
PSI - Potential for safety improvement, a positive value indicates that the location is experiencing a higher yearly number of collisions than would be expected at signalized intersections elsewhere in the Region of Durham.